JAXA Japan Aerospace Exploration Agency

Improving IV&V Methods based on Practical Data Analysis in JAXA's Spacecraft Projects

The 2012 IV&V Annual Workshop

@WVU Erickson Alumni Center

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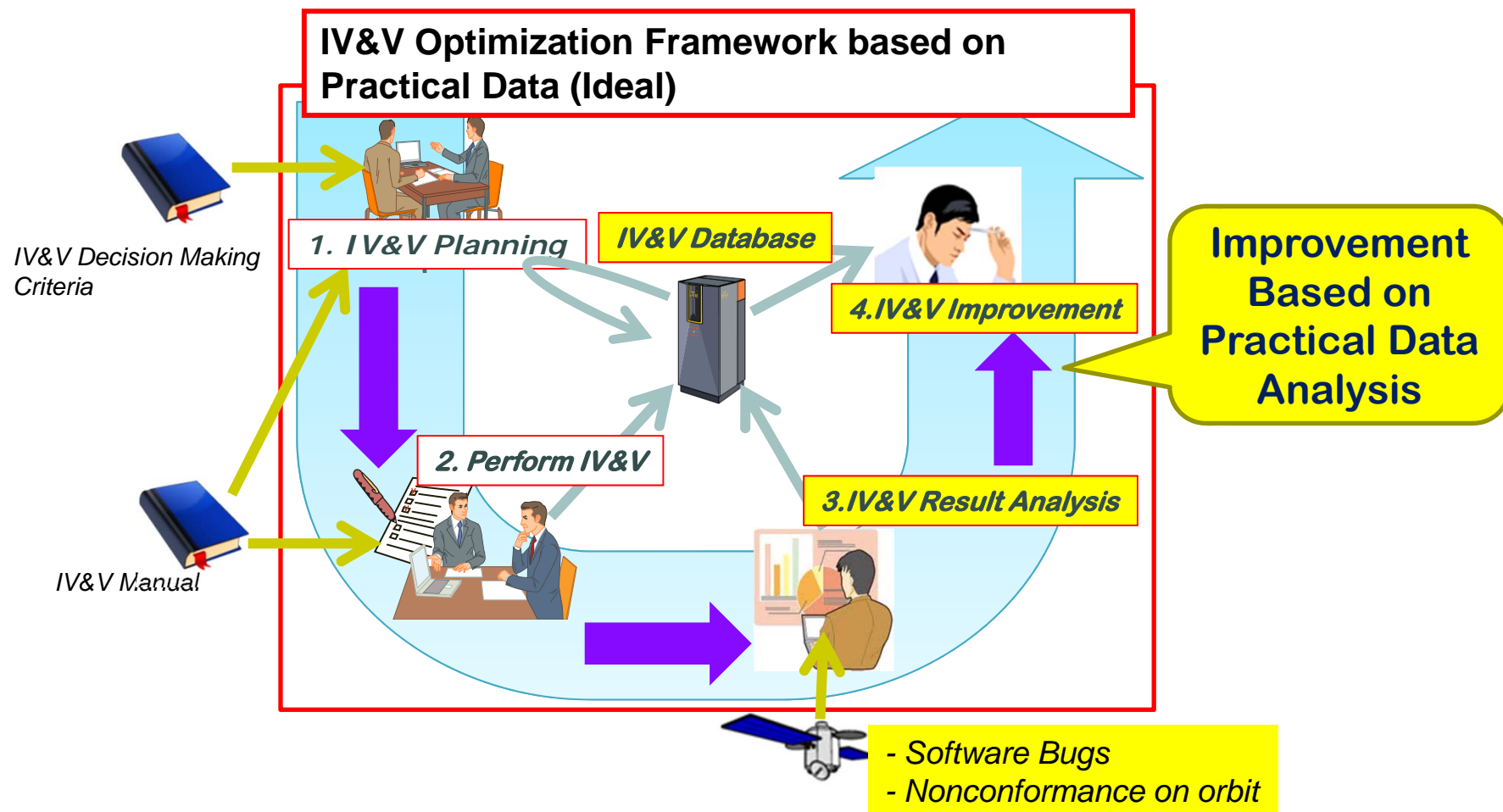*1 Japan Aerospace Exploration Agency (JAXA)

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Contents

- **Background**
  - **IV&V Lifecycle**
  - **IV&V Practical Data Analysis**
- **Analysis of IV&V Findings**
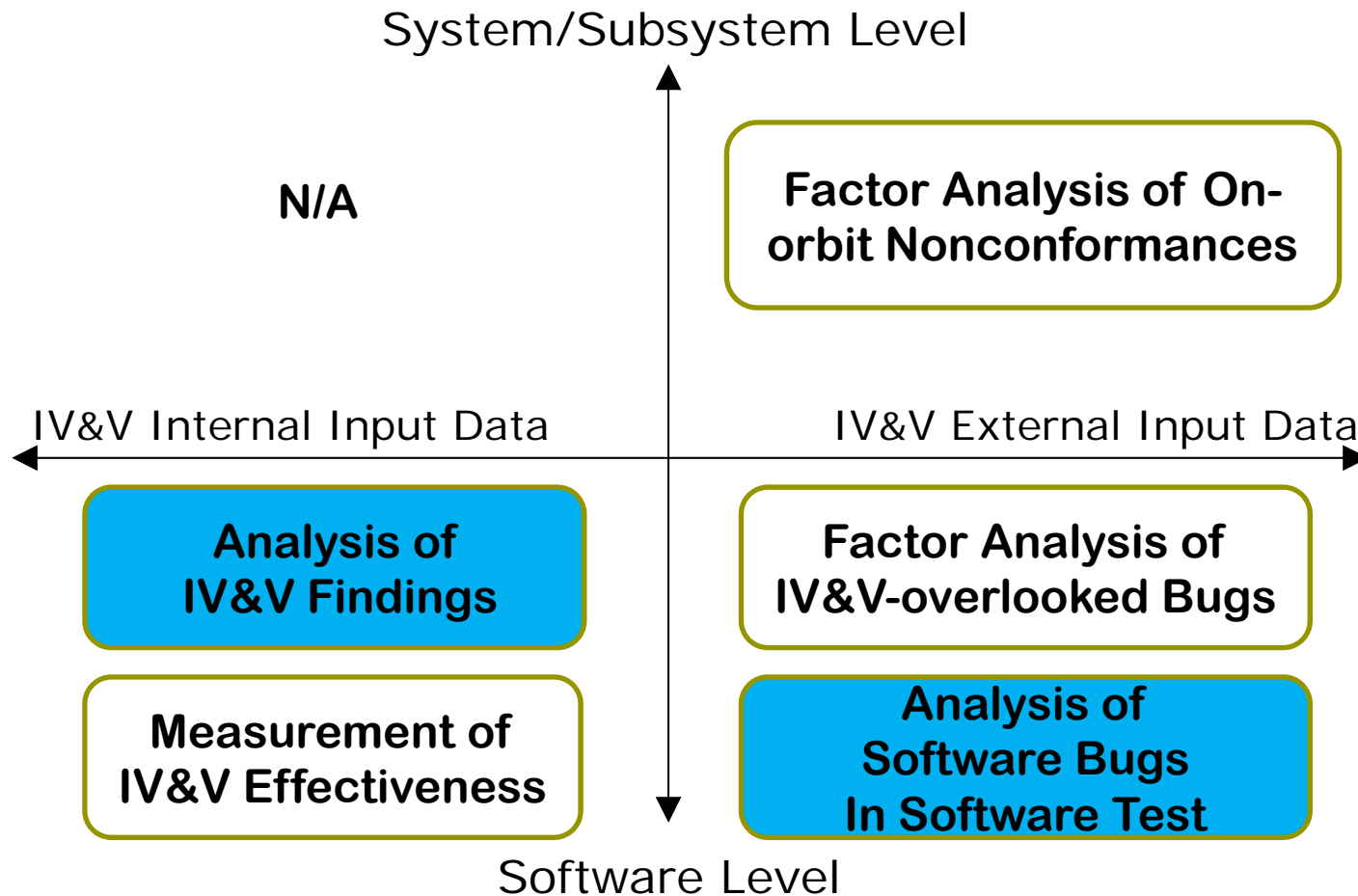- **Analysis of Software Bugs**
- **Future Work**

1.Background (1/3)

● IV&V Lifecycle

IV&V Optimization Framework based on Practical Data (Ideal)

IV&V Decision Making Criteria

IV&V Manual

1. IV&V Planning

IV&V Database

2. Perform IV&V

3. IV&V Result Analysis

4. IV&V Improvement

Improvement Based on Practical Data Analysis

- Software Bugs
- Nonconformance on orbit

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1.Background (2/3)

- **Areas of IV&V Practical Data Analysis**

System/Subsystem Level

N/A

Factor Analysis of On-orbit Nonconformances

IV&V Internal Input Data

IV&V External Input Data

Analysis of IV&V Findings

Factor Analysis of IV&V-overlooked Bugs

Measurement of IV&V Effectiveness

Analysis of Software Bugs In Software Test

Software Level

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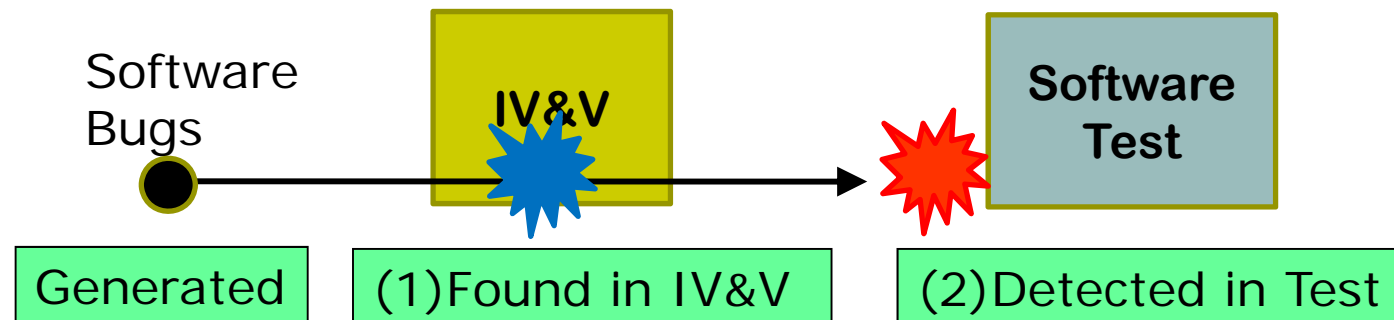
1.Background (3/3)

- **Discussion Point**

    IV&V Improvement Method based on

    the analysis and feedback regarding

    (1) IV&V Findings

    (2) Software Bugs* in Software Test

    * Bugs overlooked in IV&V and detected in Software Test

Software
Bugs

IV&V

Software
Test

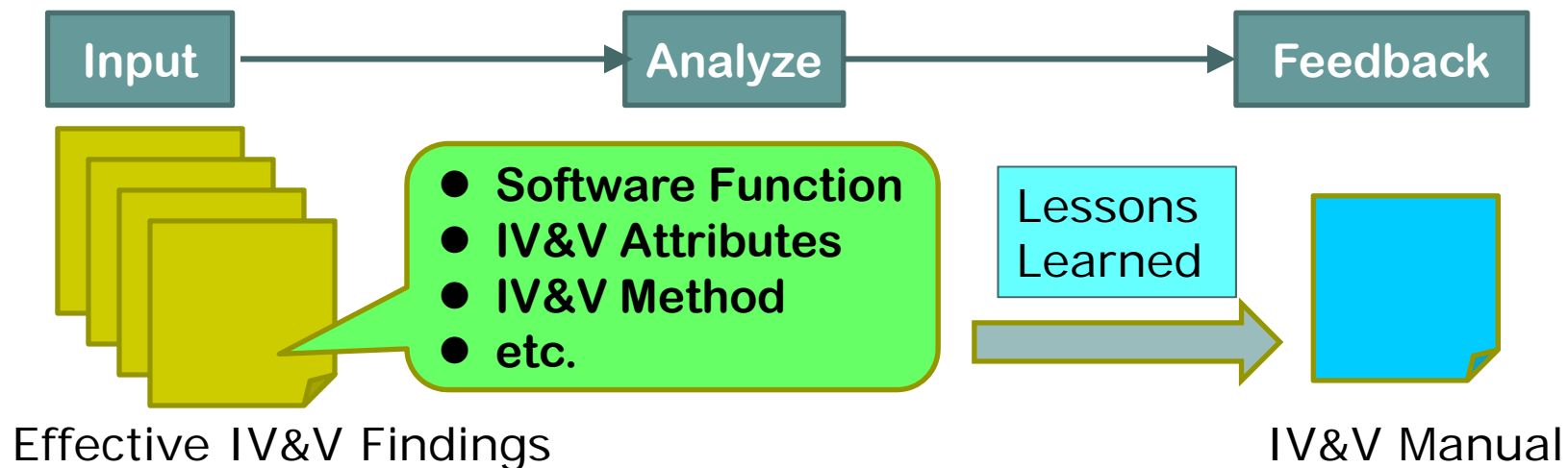| Generated | (1)Found in IV&V | (2)Detected in Test |

2.Analysis of IV&V Findings (1/5)

- **Purpose**
  - **To Analyze the IV&V method in the case of detecting Effective IV&V findings**
  - **To Feedback the Lessons Learned to IV&V methodology (IV&V manual, etc.)**

Input	Analyze	Feedback

- **Software Function**
- **IV&V Attributes**
- **IV&V Method**
- **etc.**

Lessons Learned

Effective IV&V Findings   IV&V Manual

2.Analysis of IV&V Findings (2/5)

- **Analysis**
  - ➢ **Input**

    IV&V Findings of JAXA's Past Projects

    (Satellite / Launch Vehicle / Ground System)

  - ➢ **Analysis Method**
  - ① **To Analyze Characteristics of IV&V Findings**
    - ➢ **IV&V Plan, Guideline, Method, Pre/Post Process**
  - ② **To Analyze Most Effective IV&V Findings**
    - ➢ **IV&V Procedure, How-to-detect, Characteristics**
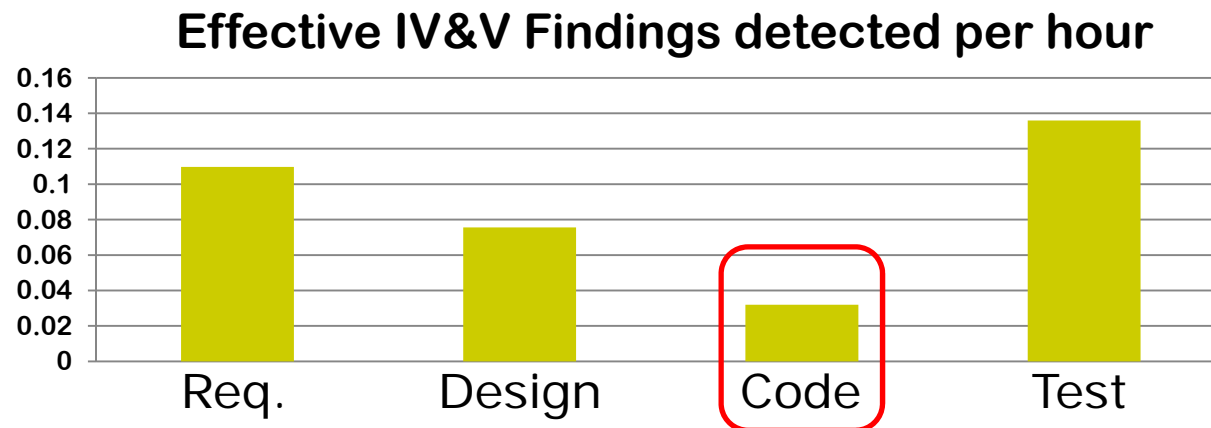
2.Analysis of IV&V Findings (3/5)

- ## Result (1)
  - ➢ **IV&V Work Efficiency of Code Phase is lower than other phases.**

[Suggestion]
Work Efficiency of Code Phase should be improved.

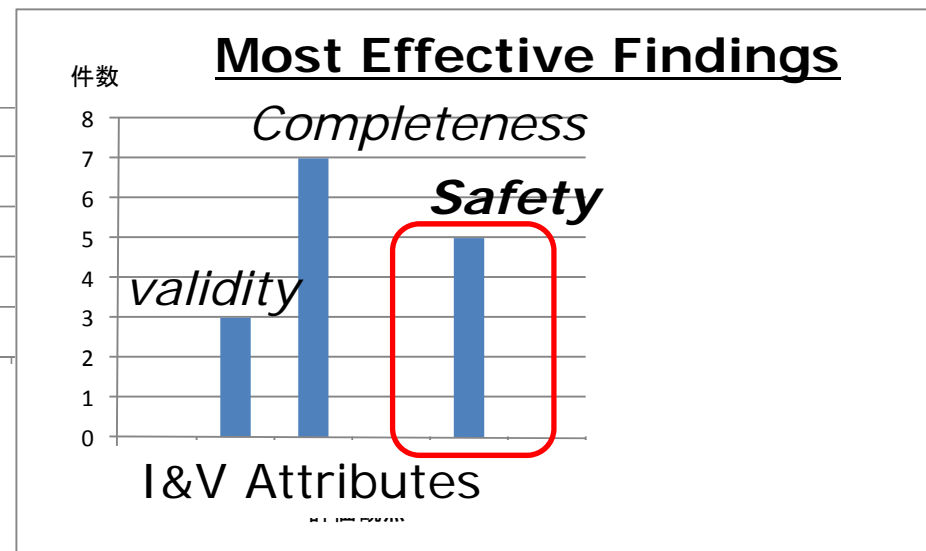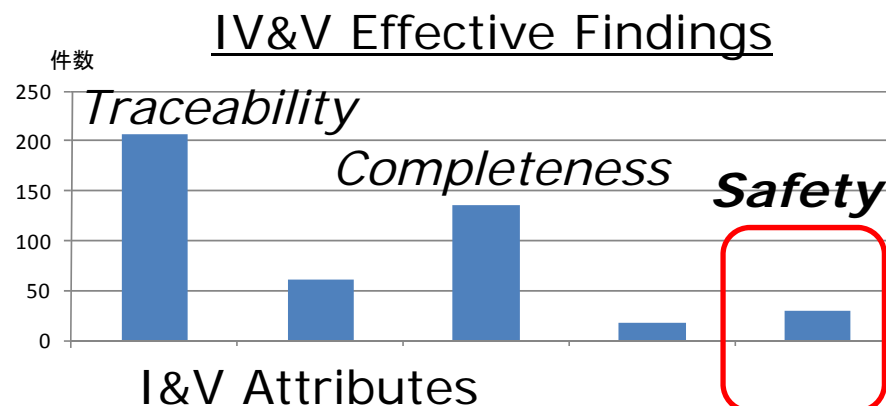**Effective IV&V Findings detected per hour**

- ## Result (2)
  - ➢ **IV&V Findings of Safety is few, however they could be most effective at a high rate**

[Suggestion]
It is necessary to increase the application of IV&V from the aspect of safety.

IV&V Effective Findings

件数

Traceability

Completeness

Safety

250
200
150
100
50
0

I&V Attributes

Most Effective Findings

件数

Completeness

Safety

8
7
6
5
4
3
2
1
0

validity

I&V Attributes

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2.Analysis of IV&V Findings (5/5)

- **Conclusion**

  ➢ **The analysis results** not depending on subjective experiences **of IV&V engineers were obtained** by quantitative analysis.

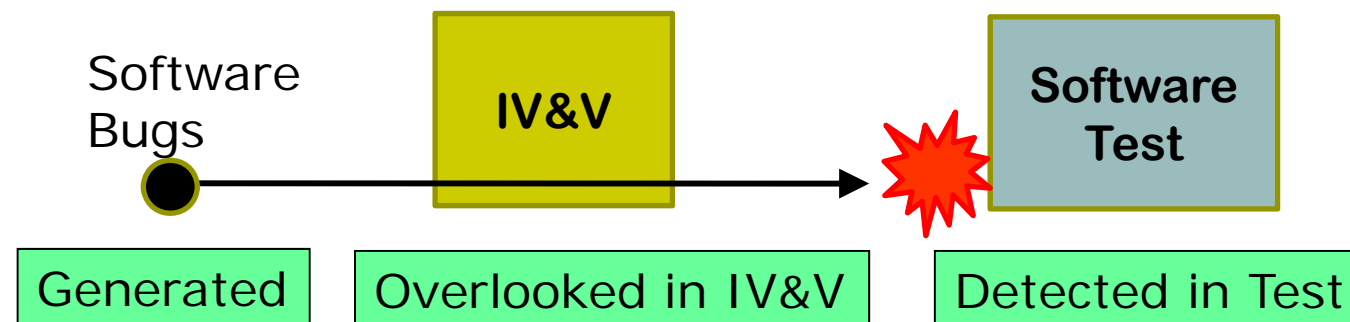 ➢ Objective Improvement Suggestion to IV&V **based on practical data became available.**

3.Analysis of Software Bugs (1/5)

- **Purpose**

  - ➢ **To analyze Causal Factors of Software Bugs* by both Software Developers and IV&V engineers**

  - ➢ **To suggest the improvement of IV&V activities based on the analysis**

  * Bugs overlooked in IV&V and detected in Software Test

Software Bugs   IV&V   Software Test

| Generated | Overlooked in IV&V | Detected in Test |

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3.Analysis of Software Bugs (2/5)

- **Analysis**
  - ➤ **Input**
    Software Bugs in Software Test regarding
    JAXA's Past Satellite Projects (62 items)

  - ➤ **Analysis Method**
    Software Developer **Software Bugs** *IV&V Engineer*
    - ➤ **By Software Developers**
      - ✓ To analyze whether IV&V can detect the bugs or not from the aspect of the development background
      - ✓ To derive the reason why IV&V can't detect the bugs
    - ➤ **By IV&V Engineers**
      - ✓ To analyze whether IV&V can detect the bugs or not from the aspect of the IV&V methodology
      - ✓ To derive improvement feedback to IV&V manual

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3.Analysis of Software Bugs (3/5)

- **Result of Analysis by Software Developer**
  - ➢ **Analysis of Bugs which are difficult to detect in IV&V**

[Example of Analysis Sheet]

Context of Software Bugs	IV&V Attribute	Difficulties to detect in IV&V	Improvement Suggestion

Detailed Information is shown at the Workshop

3.Analysis of Software Bugs (4/5)

- ● **Result of Analysis by IV&V Engineer**
  - ➢ **Analysis based on IV&V manual**

[Example of Analysis Sheet]

Context of Software Bugs	IV&V Attribute	Overlooking Factor in IV&V	The Reason why IV&V can't detect

Detailed Information is shown at the Workshop

Improvement of IV&V Plan	Improvement of IV&V Attribute	Improvement of Evaluation Item	Improvement of IV&V Method

3.Analysis of Software Bugs (5/5)

- **Conclusion**
  - ➢ **Causal Factor of Software Bugs which are** not described clearly in the Nonconformance Report **can be derived by getting complementary information from Software Developer.**

  - ➢ **The areas which are difficult to apply IV&V** even if it is technically possible to detect bugs **were identified.**
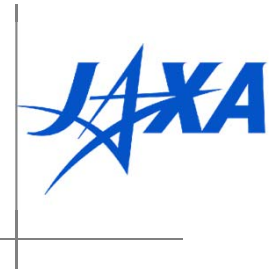
  [Improvement Suggestion]
  Scope of IV&V should be discussed and agreed with Project Team in IV&V planning

4.Future Work

- ## Analysis of IV&V Findings

  - ➢ **More Detailed Analysis including effects between multiple attributes**

- ## Analysis of Software Bugs

  - ➢ **Constructing the Framework in IV&V Lifecycle that IV&V Activities are continuously improved based on the Analysis of Software Bugs**

END